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SCIENCE 7

Module 4 Structures and Forces

Home Instructor's Guide and Assignment Booklet 4A

Learning Technologies Branch

Alberta LEARNING

Science 7
Module 4: Structures and Forces
Home Instructor's Guide and Assignment Booklet 4A
Learning Technologies Branch
ISBN 0-7741-2443-1

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The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Home Instructor's Guide and Assignment Booklet.

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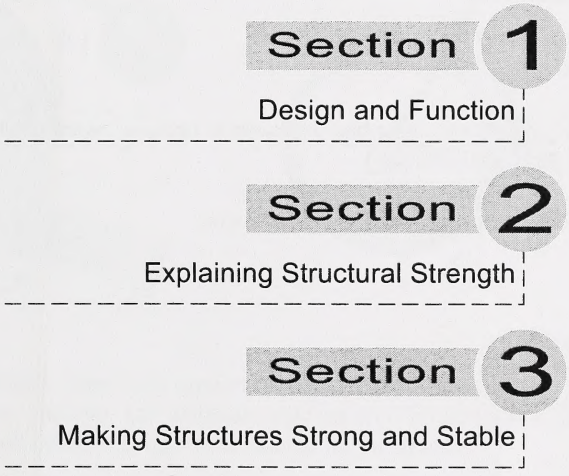
Module 4: Structures and Forces

The major emphasis of this module is **Science and Technology**. That is, the focus is on science-based solutions to practical problems.

Structures serve a variety of purposes and take a wide range of forms. In learning about structures, the student investigates the properties of materials used and tests them under different loads and forces. The student then examines different ways structural components are configured, analyzes forces involved, and investigates resulting effects on structural strength and stability. As part of his or her study, the student also examines construction methods used in the past and the present and learns how science and technology link together in developing safe and efficient designs that meet human needs.



Key Concepts

The following concepts are developed in this module and may also be addressed at other grade levels.

- structural forms
- material strength and stiffness
- joints
- forces on and within structures (loads and stresses)
- direction of forces
- deformation
- structural stability
- modes of failure
- performance requirements
- margin of safety

Assessment

In this module, students are expected to complete three section assignments and a final module assignment. Their grading in this module is based on the assignments they submit. The mark distribution is as follows:

Assignment Booklet 4A	
Section 1 Assignment	35 marks
Section 2 Assignment	34 marks
Assignment Booklet 4B	
Section 3 Assignment	24 marks
Final Module Assignment	27 marks
TOTAL	120 marks

Section 1: Design and Function

In this section, the student classifies and describes structures to become aware of the relationship between properties of structures and their functions.

The following materials will be needed to complete this section.

Section 1: Lesson 1

- 20 large, thick, plastic straws
- 15 small paper clips
- 60 cm of masking tape
- 1 golf ball
- scissors

Section 1: Lesson 2

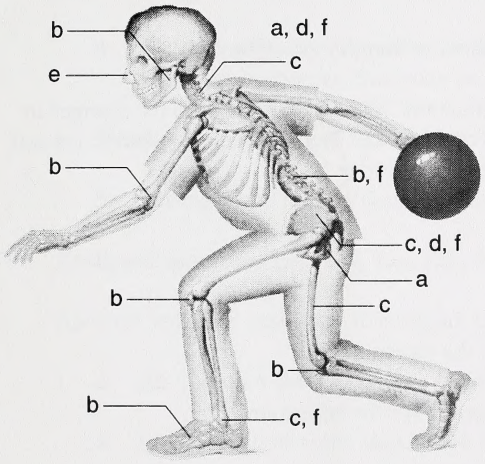
- magnifying glass
- several brands of facial tissues (including one- and two-ply)
- an empty, open-topped container (e.g., an empty 1-L coffee tin)
- 600–800 pennies (or washers)

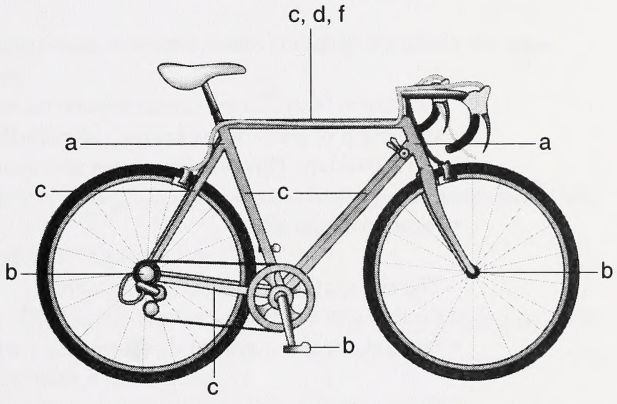
Suggested Answers

Section 1: Lesson 1

3. **Textbook questions 1, 2, and 3 of "Procedure," p. 275**

1. and 2.





3. The purpose of the bicycle frame is to support the weight of a rider and have the wheels, pedals, gears system, and handlebars attached. The materials used are well suited for this purpose because they are strong, lightweight, and flexible enough to withstand minor stresses.

   The purpose of the human skeleton is to support the weight of the body, provide muscle and ligament attachment points, and protect the internal organs. Bone is well suited for this purpose because it is lightweight, strong, and flexible.

4. a. **Textbook questions 1, 2, and 3 of "Evaluate," p. 277**

   Answers will vary. Sample responses are given.

   1. No, the golf ball rolled off.

   2. No, the track was too narrow.

   3. It was hard to construct the bridge within 40 minutes. Too many adjustments had to be made.

b. **Textbook question 5 of "Extend Your Knowledge," p. 277**

5. The following are additional things you may consider:

- weight and speed of the trains crossing the bridge

  Extra weight requires more support. The speed of the train may result in a pounding action, which puts greater strain on the bridge than a stationary load.

- climate of the location (temperature range and annual or monthly precipitation)

  Change in temperature causes expansion and contraction. Without an allowance for changes in the length or parts of the bridge, dangerous stress can develop. Precipitation may lead to ice and snow buildup. This buildup places additional load on the bridge.

- location of the site

  The site may be geologically unstable.

- topographical features of the gorge (e.g., width of the river)

  If the gorge is wide, additional supports will be needed for the bridge structure.

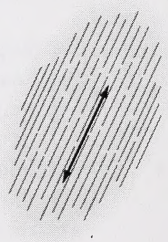
Section 1: Lesson 2

8. **Textbook questions 1, 2, and 3 of "What Did You Find Out?," p. 287**

1. Whether the grains are in the same direction or not depends on the brand of tissue.

   The strongest arrangement will be the one in which the adjacent layers have the direction of the grain perpendicular (at right angles) to each other.

   It would be easiest to tear tissue in which the grains are all in the same direction. The tear should be in the direction of the grains.



2. The fibres are pressed together. There are no fibres that go over and under other fibres.

3. The tearing is somewhat easier in the direction of the grain.

10. a. **Textbook questions 1 to 4 of "What Did You Find Out?," p. 289**

1. Multi-ply tissues are generally strongest.

2. The fibre pattern (parallel or crisscrossed) and the number of layers make a tissue stronger.

3. Other properties affecting function or sales are softness, added lotion and scent, colour, price, and the type and appearance of the dispenser.

4. Answers will vary depending on the tissues tested. Strength and absorbency are likely the most important properties. Size may be another.

b. **Textbook question 5 of "Extension," p. 289**

5. Testing damp or wet tissues is a fairer test for strength because tissues usually get damp during use.

17. **Textbook questions 1.a., 1.b., 1.c., 1.d., 1.f., and 3 of "Analyze," p. 295**

Answers will vary according to structure chosen. The sample answers given are based on choosing an igloo.

1. a. An igloo is a shell structure. An individual built it as a shelter.

b. Blocks of snow were used. Snow is close at hand and there is lots of it.

c. The Inuit built igloos mainly for shelter in the frozen Arctic. They were spherical with a thick outer wall for strength and insulation.

d. The igloo was designed simply for its functionality, not for aesthetics.

f. Construction of an igloo is as follows:

step 1: Cut blocks of compacted snow from a snowdrift (approximately 60 cm by 80 cm by 30 cm).

step 2: Put down one row of blocks in a circle.

step 3: Shave off the top edge of first row to start a spiral.

step 4: Put down additional blocks along the sloped edge of first layer to start a spiral going upwards and to the centre. Leave a hole at the top for ventilation.

step 5: Pack soft snow into joints and crevices.

step 6: Add an entrance channel, also made of snow.

3. Answers will vary. The answer involves speculation.

   Different cultures deal with science in different ways. The scientific knowledge needed for the construction of an igloo or most other structures is very similar. The way this knowledge is learned and applied will be different. For a successful igloo, the builder has to handle the stresses, loads, and characteristics of the building materials just like those who build wood-frame houses have to.

Section 2: Explaining Structural Strength

In this section the student investigates the concepts of mass and weight and defines the term *force*. He or she then identifies and classifies external and internal forces to which structures and materials are subjected. The student examines how these forces can threaten structural failure.

The following materials will be needed to complete this section.

Section 2: Lesson 1

- 10 straws
- 30 cm of tape
- 10 paper clips or pins
- 250-mL plastic (or Styrofoam®) cup
- sand
- piece of wood (15 × 30 cm)
- assorted objects for weight
- force meter
- newspaper
- 3 or 4 shell structures (e.g., ice-cream cone, plastic cup, egg shell, cannelloni pasta)

Section 2: Lesson 2

- 5 large marshmallows
- black, non-permanent felt pen
- ruler
- 2 pairs of scissors (1 dull, 1 sharp)
- toothpicks
- 2 pieces of blue polystyrene (10 × 15 cm)
- paper
- small towel or washcloth
- 2 plastic buckets with handles
- water
- graduated cylinder (or measuring cup in mL)
- rubber gloves
- 2 desks or tables
- a strong wooden or metal bar
- paper clips
- assorted masses of known weight
- 4, 30-cm lengths of material (e.g., thread, fishing line, tape, paper)

Suggested Answers

Section 2: Lesson 1

11. a. **Textbook questions 1, 2, and 3 of "Analyze," p. 303**

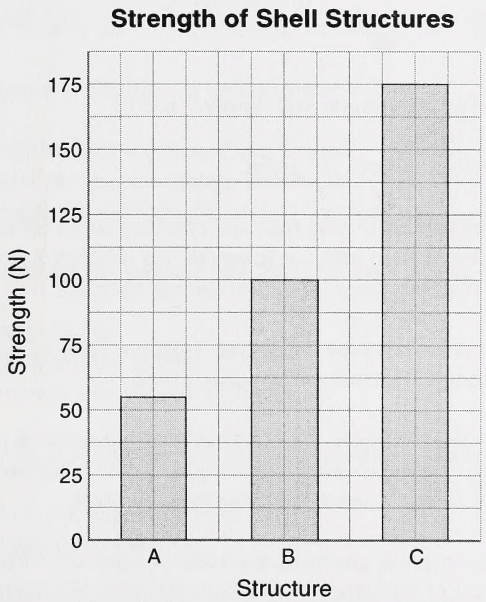
1. The manipulated variable was the type of shell structure tested.

   The responding variable was the force, measured in newtons (N), required to crush the structure.

   The controlled variables were the distribution of the force over a uniform area using a platform supporting the weights, the weights used, the room temperature, and the air pressure.

2. Answers will vary. A possible ranking from weakest to strongest is paper muffin tin liner, ice-cream cone, shell-shaped pasta.

3. Graphs will vary. A sample graph is given.



b. **Textbook questions 4, 5, and 6 of "Conclude and Apply," p. 303**

4. Answers will vary. Sample answers are given.

   a. The arch seemed strongest. The shell-shaped pasta was strongest. It had an arch shape.

   b. The pasta material seemed to be the strongest. It was very rigid.

5. Applying the force quickly or concentrated at one point will cause the structure to fail more easily.

6. a. helmets, bottles, shoulder pads, kneepads, eggs, etc.

   b. balloons, beach balls, etc.

Section 2: Lesson 2

7. a. **Textbook question 1 of "Analyze," p. 313**

   1. a. False. Bending, shearing, and torsion forces involve compression and tension.

      b. True. Torsion does reduce the space between particles of a material.

      Note: Tension is also a factor during torsion stress.

      c. True. Several fibres twisted into a yarn are stronger than a single fibre.

      d. True. Bending causes tension when the ends of a structure are bent down and compression when the ends are bent up.

   b. **Textbook questions 3 and 4 of "Conclude and Apply," p. 313**

      3. Answers will vary. Sample structures are given.

      Tension: Steel chains and cables, fishing line, and climbing ropes are made of materials with high tensile strength and are designed to take advantage of this property to withstand large pulling forces. For example, cables are made of many strands of thinner material.

      Compression: Concrete columns, shoe soles, and floors are made of materials with high compressive strength and are designed to withstand compressive forces.

      Torsion: Bolts, drive shafts of engines, drill bits, and skis are made of materials with high torsional strength and are designed to take advantage of this property to withstand twisting forces. For example, drive shafts are carefully machined from flawless steel.

      Shear: Reinforced concrete, nails, and bolts are made of materials with high shear strength and are designed to take advantage of this property to withstand shear. For example, the steel rods in reinforced concrete resist shear forces.

Bending: Skis and ski poles, fishing rods, bridge decks, and tent poles are made of materials with high tensile and compression strengths and are designed to take advantage of this property to withstand repetitive tension and compression forces. For example, skis are laminated using materials with high compressive strength near the top and high tensile strengths near the bottom.

Note: A bending force is due to two forces acting within an object at the same time. These forces are compression and tension. When an object is bent, there is a compression force on the inside of the bend and is a tension force on the outside of the bend. Because a bending force is based on compression and tension, some people do not consider it a separate force. Yet, others recognize it as special force because the internal forces act at the same time. In this investigation bending is identified as a separate force.

4. a. The internal stresses of a playground swing set are as follows:

   - compression and tension in the vertical supports
   - tension and torsion in the chains or rope
   - bending in the seat and horizontal support
   - shear and tension in the bolts connecting the seat to the chains or rope

   b. The internal stresses of a playground seesaw are as follows:

   - bending of the horizontal beam of the seesaw
   - compression of the central support (fulcrum)
   - shear and tension in the bolts connecting handles to the seesaw

   c. The internal stresses of a full garbage bag held shut with a twist-tie are as follows:

   - torsion in the twist-tie
   - tension in the plastic of the bag
   - compression on the content of the bag

   d. The internal stresses of a front bumper of an automobile are as follows:

   - compression at the mounting bolts
   - tension and torsion in the bolts

   e. The internal stresses of a member of a school's wrestling team during a match are bending of arms and legs.

   f. The internal stresses of a snowboard with bindings are as follows:

   - bending and torsion on the board
   - tension and torsion on the bindings
   - shear and tension on the mounting screws

ASSIGNMENT BOOKLET 4A

Science 7
Module 4: Section 1 Assignment and Section 2 Assignment

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- Has your work been reread to be sure the spelling and details are correct?
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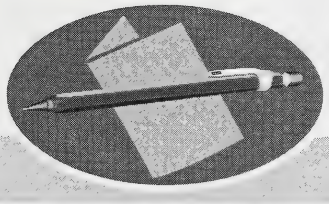
Science 7

Module 4

Structures and Forces

Assignment Booklet 4A



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Summary

	Total Possible Marks	Your Mark
Section 1 Assignment	35	
Section 2 Assignment	34	
	69	

Teacher's Comments

Science 7
Module 4: Structures and Forces
Assignment Booklet 4A
Learning Technologies Branch

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ASSIGNMENT BOOKLET 4A
SCIENCE 7: MODULE 4
SECTION 1 ASSIGNMENT AND SECTION 2 ASSIGNMENT

Your mark for this module will be determined in part by how well you do your assignments.

This Assignment Booklet is worth 69 marks out of the total 120 marks for the assignments in Module 4. The value of each assignment and each question is stated in the left margin.

Work slowly and carefully. If you have difficulty, go back and review the appropriate topic.

Be sure to proofread your answers carefully.

35

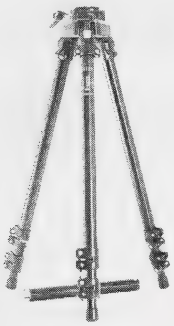
Section 1 Assignment: Design and Function

Read all parts of your assignment carefully and record your answers in the appropriate places.

3

1. a. For each of the following structures, state whether it is a mass, frame, shell, or mix and match structure.

A.



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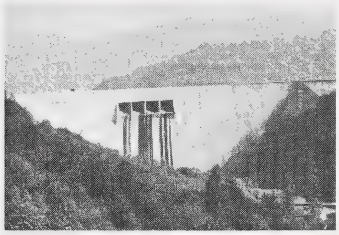

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b. For each structure in question 1.a., explain why you chose the type you listed.

(1) **A:** _____

_____

(1) **B:** _____

_____

(1) **C:** _____

_____

Read question 2 carefully. Decide which of the choices BEST answers the question. Place your answer in the blank space given.

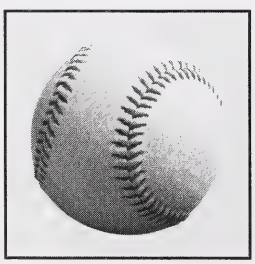
(1) _____ 2. Which of the following is a natural structure?

A. grass hut
B. igloo
C. turtle shell
D. balloon

Return to page 20 of the Student Module Booklet and begin Lesson 2.

3. Use the photographs to answer the following questions.

A.



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B.

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(2) a. How are the two structures similar?

_____

_____

_____

(2) b. How are the two structures different?

_____

_____

_____

4. Compare the functions and materials of these three human-made structures.

North American 13th Century (1200s)

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Asian 21st Century (2000s)

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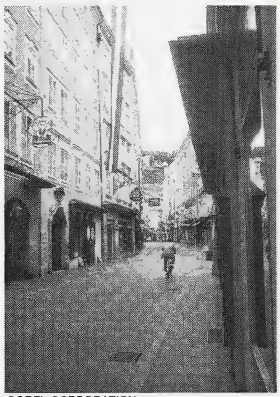
European 17th Century (1600s)



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(2) **Functions:** _____

_____

_____

(2) **Materials:** _____

_____

_____

Return to page 23 of the Student Module Booklet and continue with Lesson 2.

(2) 5. The human body is a mixed structure. What role do bones play in this structure? What role do ligaments play in the body's joints?

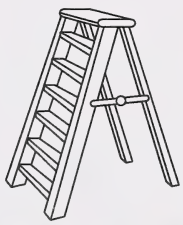
_____

_____

_____

(4)

6. This stepladder has several fixed joints and several hinged joints. Label two fixed joints and label two hinged joints.



Return to page 26 of the Student Module Booklet and continue with Lesson 2.

(4)

7. A concrete-block retaining wall, used to hold back a mass of earth from a road, is a mass structure. Describe two ways the retaining wall can fail.

(4)

8. You are asked to design a structure to house a push mower, a small wheelbarrow, and assorted garden tools. What type of structure design will you choose? Support your decision with reasons for your choice.

(6)

9. Match each item in Column A with its appropriate example in Column B. Place your answer in the blank space given.

Column A	Column B
_____ composite material	a. concrete driveway
_____ layered material	b. gas pipeline
_____ woven material	c. human knee
_____ glued joint	d. parachute
_____ welded joint	e. Tetrapak™
_____ hinged joint	f. wooden pencil

Return to page 29 of the Student Module Booklet and begin Section 2.

(34)

Section 2 Assignment: Explaining Structural Strength

Read all parts of your assignment carefully and record your answers in the appropriate places.

1. What are the units of force and mass in the SI system?

(1) **force:** _____

(1) **mass:** _____

Read question 2 carefully. Decide which of the choices BEST answers the question. Place your answer in the blank space given.

(1) _____ 2. If you were asked for your weight, which would be the best unit to use?

A. gram
B. kilogram
C. newton
D. decibel

Return to page 36 of the Student Module Booklet and begin Lesson 2.

(5)

3. Match each object in Column A with its characteristic in Column B. Some items from Column B may not be used. Place your answer in the blank space given.

Column A	Column B
_____ a bird's egg	a. colour
_____ a bird's nest in a tree	b. dead load
_____ related to gravity	c. frame structure
_____ Rocky Mountains	d. mass structure
_____ a tree branch	e. shell structure
	f. symmetry
	g. weight

4. A block of butter has a mass of 454 g.

(1)

a. Express the mass of the block of butter in kilograms.

(1)

b. What is the weight on Earth of the 454-g block of butter? (**Hint:** See the "Math Connect" on page 304 of the textbook.)

5. When you hang an object from a spring scale, the spring stretches so the force of the spring opposes the downward force acting on the object.

(1)

a. What is the downward force on the object called?

_____

(1)

b. How large is the upward force exerted by the spring?

_____

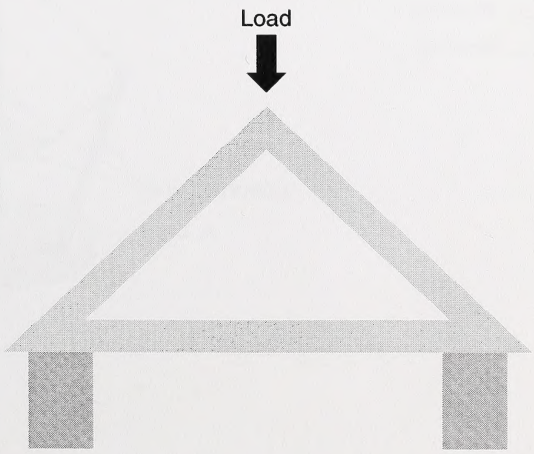
(4) 6. Draw a correctly labelled force diagram showing the forces acting on a textbook resting on a desk.

(2) 7. Why does the weight of an object, as measured on a spring scale, change when measured on Earth and then on the Moon?

_____

_____

(5) 8. The diagram given shows a truss design often used for roofs of small buildings, such as a garage. On the diagram, indicate which members are under tension and those under compression.

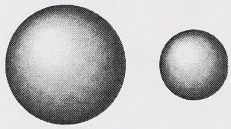


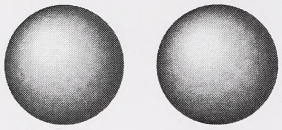
Read question 9 carefully. Decide which of the choices BEST answers the question. Place your answer in the blank space given.

(1)

_____ 9. Which of the following pairs of objects has the greatest gravitational attraction?

A.

B. 

C. 

D.

(2)

10. List one live load and one dead load of a person riding a bicycle.

_____

_____

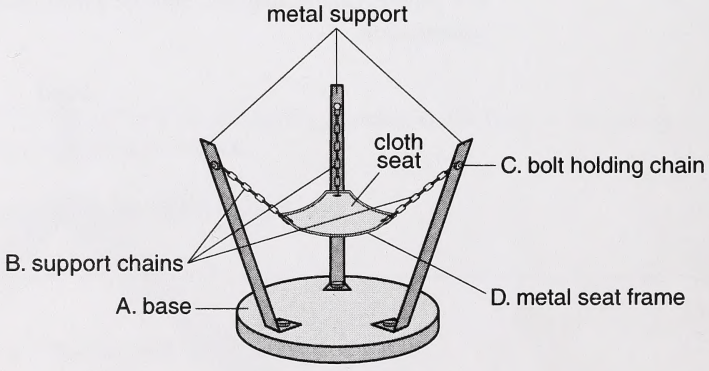
_____

Return to page 41 of the Student Module Booklet and begin Lesson 3.

(4)

11. A diagram of a chair is given. Several parts have been labelled with the letters A to D. Match the letter of the chair part with the kind of force it would experience when someone sits in the seat.

_____ tension
_____ compression
_____ shearing
_____ bending



(1) 12. a. What property of a chain makes it suitable for its use in the chair in question 12?

(1) b. What property of a chain makes it unsuitable to replace the metal supports in the chair?

(2) 13. "Stresses can be both useful and destructive at the same time." Use buckle stress to explain this statement.

Submit your completed Assignment Booklet 4A to your teacher for assessment.
Then return to page 45 of the Student Module Booklet and begin Section 3.

ASSIGNMENT BOOKLET DECLARATIONS

The Student's Declaration is to be signed by a student registered at the Alberta Distance Learning Centre. If the student is under 16, the Supervisor's Declaration is to be signed by the student's supervisor, who is usually a home instructor, teacher, or home-schooling coordinator. Failure to complete this page may invalidate the assignment results.

STUDENT'S DECLARATION

- I have followed the instructions outlined in the Student Module Booklet.
- I have completed the activities to prepare myself for the assignments in this Assignment Booklet.
- I completed the assignments in this Assignment Booklet by myself.

_____

Student's Signature

SUPERVISOR'S DECLARATION

I hereby certify that I have supervised the learning activities completed by _____.

Student's Name

I also certify that to the best of my knowledge the assignments in this Assignment Booklet were completed independently by this student.

_____

Supervisor's Signature

If you, the student or supervisor, have any comments or observations regarding this module, write them in the following space.

_____

_____

_____

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